On the Loch-Leven Trout (*Salmo levenensis*).

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Salmo levenensis, *Walker*.

Salmo levenensis, *Walker*, *Wernerian Memoirs*, i. p. 541 (1808), *apud Neill*; *Walker*, *Posthumous Essays on Natural History* (1812); *Yarrell*, *Brit. Fishes*, (ed. 2) ii. p. 117, (ed. 3) i. p. 257; *Günther*, *Catal. of Fishes*, vi. p. 101; *Couch*, *Fishes Brit. Isles*, iv. p. 243, pl. ccxx.; *Houghton*, *Brit. Freshwater Fishes*, p. 123, c. fig.; *Day*, *British and Irish Fishes*, ii. p. 92, pl. cxvi. figs. 2 & 2 *a*.

Salmo taurinus, or Loch-Leven Bull-Trout, *Walker*, *Essays*, *l. c.* (large examples).

Loch-Leven Trout, *Richardson*, *Fauna Bor.-Americana*, 1836, p. 143; *Knox*, *Proceedings Linnean Society*, vol. ii. p. 354, Dec. 1854.

Salmo cæcifer, *Parnell*, *Fishes of the Firth of Forth*, p. 306, pl. xxx., *and Wern. Mem.* vii. p. 146, pl. xxx.

Among the general public, anglers, and fishermen it has, from almost time immemorial, been a subject of argument as to whether the Loch-Leven trout should be considered a species distinct from the burn-trout (*Salmo fario*); and also, supposing it to be a distinct species, whether it may not be the descendant of a marine form which, having ascended the river Leven and obtained access into the loch from the sea, has been unable to return there. Scientific men have joined in this discussion and given or refused specific rank to the Loch-Leven trout; in the meantime, the form in question has been selected as the stock-fish for the justly celebrated Howietoun fish-farm of Sir James Maitland, which is within 25 miles of Loch Leven and at about the same elevation above the sea, and here facilities have existed for studying the race more closely, perhaps, than any other of our British trout.

In Sir Robert Sibbald's history of Kinross-shire, 1710, we read:—"Loch Leven abounds with fine fish, such as the salmonds*,

* The term salmond was used so vaguely by some authors as applicable to both the salmon and sea-trout, that the simple name being given is hardly sufficient evidence of the presence of *Salmo salar*. Thus Sir R. Sibbald, in his 'Scotia Illustrata,' 1684, divided salmon from salmoneta, and referred to the latter as follows:—"Salmoneta, qui nostratibus the *Salmon-trout*" (p. 25). He also observed, "The Grey trout, or Bill-trout, some of them as large as a salmond"; but, as I shall show, this grey stage is not the livery of old specimens, and none have been recorded over 10 lb. in weight, it would therefore seem he referred to sea-trout; again, silvery trout in Scotch lochs are often classed as sea-trout.

taken in the summer . . . . The Grey-trout or Bill-trout, some of them as big as a salmond; greyish skinned and red fished, a foot long, taken all the year over. Cendue or Camdue in Irish, Blackhead, having a black spot on the top of its head, is fat, big as a Dunbar herring, red fished, much esteemed."

Pennant, in 1769, went to Loch Leven, and observed:—"The fish of this lake are pike, small perch, fine eels, and most excellent trouts, the best and the reddest I ever saw; the largest about 6 lb. in weight" (Journ. 4th ed. p. 69). In his 'British Zoology,' 1776, he did not refer to any distinct species existing in Loch Leven; but after remarking on the large trouts of Lough Neagh in Ireland, locally termed Buddaghs, he continued, "Trouts (probably of the same species) are also taken in Hulse-water, a lake in Cumberland, of a much superior size to those of Lough Neagh. These are supposed to be the same with the trout of the lake of Geneva, a fish I have eaten more than once, and think but a very indifferent one" (iv. p. 299).

The Reverend A. Smith, 'Statistical Account of Kinross,' 1793, remarked that "In Loch Leven are all the different species of hill, burn, and muir trout that are to be met with in Scotland, evidently appearing from the diversity of manner in which they are spotted; yet all three different kinds, after being two years in the loch and arriving at $\frac{3}{4}$ lb. or 1 lb. in weight, are red in the flesh, as all the trout of every kind in the loch are, except, perhaps, those newly brought down by the floods, or such as are sickly. The Silver-grey trout, with about four or five spots on the middle of each side, is apparently the original native of the loch, and in many respects the finest fish of the whole. The fry of all kinds are white in the flesh till they come to the size of a herring, about the beginning of the third year. . . . . Those called bull-trout are believed to be the old ones. In spring, 1791, a large one was caught that weighed 10 lb."

Dr. Walker, in his posthumous 'Essays on Natural History and Rural Economy,' 1812, observed of the trout in Loch Leven:—"The first most frequent is called at the place *Grey Trout*, and is a fish not distinctly described by naturalists; it is found usually from 1 lb. to 2 lb. in weight, at times considerably larger. This is supposed to be *Salmo levenensis*, N. The second, called by the inhabitants Bull-trout, *Salmo taurinus*, N., supposed to be a distinct species; but there is reason to suppose this is the male of the above. These two are generally known in Edinburgh as

Loch-Leven trout. The third is called at Kinross the *Camday*, is 8 in. to 10 in. long, and reckoned a distinct species; but is only the grey trout at an early age." He likewise referred to three more species as the Burn trout, the Highland or Muir trout, and another form of bull trout, which he does not appear to have seen, found in the deep parts of the lake, attaining to 7 lb. or 8 lb. in weight, and with yellow flesh.

Graham, 'General Review of the Agriculture of Kinross and Clackmannan,' published about the commencement of the present century, after giving an account of the fish found in Loch Leven, remarked, "Flounders are also found in Loch Leven," which demonstrated that at this period sea-fishes were able to obtain access up the river Leven into the lake.

In the year 1874, Mr. R. Burns Begg, the ex-president of the Kinross Fishing Club, compiled an interesting account of the Loch-Leven trout, and of the locality which it inhabited. The Loch-Leven lake, prior to 1830, covered a superficial area of 4312 acres; it is situated 360 feet above the sea-level, and receives the waters of the Garny and of the north and south Queich; while the mean flow from it throughout the year amounts to 4000 cubic feet a minute, which goes into the river Leven, and this river, after a course of 14 miles, falls into the Firth of Forth. In December, 1830, the loch was diminished to three fourths of its original dimensions, or to 3543 acres, by an extensive drainage operation, which permanently reduced its natural level to the extent of four and a half feet, and means were likewise devised by which, when desired, another four and a half feet can be drawn off. Fleming made a careful inspection of the loch during the years 1834 and 1835, in order to ascertain what effect the drainage had had upon its fisheries, and he concluded that they were permanently diminished one-third in their value, the sluices acting injuriously to young fish by reason of the strong current at the outflow; and that the margin of the lake had undergone a change unfavourable to its piscine inhabitants, owing to the peculiar barrenness of the shore rendering the new margin ill suited for supplying them with food. In the lake itself, however, the water-snails were found not to have been destroyed.

Many have supposed that the superior flavour of Loch-Leven trout is a consequence of the quality and abundance of the food which they could obtain there.

In the 'New Statistical Account of Scotland,' mention is made

of a trout taken April 27th, 1841, that weighed 10 lb., being 27 inches long and 17 inches in girth. We are likewise told of the fish in this lake, that their superiority in quality is not confined solely to the Loch-Leven trout proper, but is to be observed in the common trout, and even in the pike, perch, and eels; also that the trout of Loch Leven do not continue to exhibit the same distinctive superiority when they are removed to other waters. In new quarters, however favourable such may appear to be, they are said to invariably deteriorate and lose much of their quality.

The peculiarly excellent food in the water at Loch Leven has been supposed to consist of a small reddish-coloured mollusk, believed to be restricted to the shallow shingly beds lying near to the shores (the form here alluded to would seem to be a *Limnæa*), and the sessile-eyed crustacean, "screw" or "water-shrimp," *Gammarus*. Mr. Wilson concluded that it was owing to the abundant and perpetual breeding of these and other living creatures that the trout in question owed their superiority. A fisherman, however, who had the management of the curing of the trout, and had observed the food taken from their stomachs, remarked that he had never observed any small shells, but mostly worms, minnows, perch, and young trout. Furthermore, evidence was adduced by fish-dealers and others who had been regularly supplied with trout, both before and since the drainage, who distinctly stated that they could observe no deterioration whatever in the fish. Parnell, however, held a different view; and there cannot be a doubt that the stock of fish largely diminished from some cause.

Whether this form is or is not the *Salmo cumberland* of Lacépède, in his 'Histoire Naturelle des Poissons,' vol. v. p. 696, cannot now be determined from the meagre description which has been handed down to us; but that author described it as having a small head, white flesh, and being externally of a grey colour. A correspondent of Loudon's 'Magazine of Natural History,' 1832, vol. v. p. 317, remarked upon a form of trout which was found in Ulswater and Windermere, termed by the residents a "grey trout" and having the habits of a char, which he likened to Lacépède's fish, and asserted was captured up to 20 lb. weight. Parnell in 1838, *l. c.*, appears to be the first who scientifically investigated this form of trout, and from his remarks we learn that he considered "the differences that

exist between *S. cæcifer* (as he termed this form) and *S. fario* are very striking. The pectorals of *S. cæcifer*, when expanded, are pointed; in *S. fario* they are rounded. The caudal fin in *S. cæcifer* is lunated at the end; in *S. fario* it is sinuous or even. *S. cæcifer* has never any red spots; *S. fario* is scarcely ever without them. The caudal rays are much longer in *S. cæcifer* than in *S. fario*, in fish of equal length. In *S. cæcifer* the tail-fin is pointed at the upper and lower extremities; in *S. fario* they are rounded. The flesh of *S. cæcifer* is of a deep red, that of *S. fario* is pinkish or often white. The cæcal appendages in *S. cæcifer* are from 60 to 80 in number; in *S. fario* I have never found them to exceed 46." He also observed that this fish does not appear to be peculiar to Loch Leven, as he had seen specimens that had been taken in some of the lakes of the county of Sutherland.

Sir John Richardson, in the 'Fauna Boreali-Americana,' *l. c.*, remarked that in "external form, the proportional size of various parts of the head and gill-covers, the size of the scales and the dentition, agrees with *S. lemanus* . . . . . Three individuals of the Loch-Leven trout that were dissected had each 73 pyloric cæca, and in one of them 59 vertebræ were counted." Yarrell added nothing to the previous descriptions. Knox, 'Lone Glens of Scotland,' 1854, observed of this trout of Loch Leven, that it "is a beautiful silvery dark-spotted trout, imagined by some to be peculiar to the lake. This, however, is not likely, since trout quite resembling those of Leven are found in many northern lakes" (p. 36). He concluded, after citing some of the opinions of others, that he was "disposed to think that two species of trout inhabit Loch Leven, independent of the common river trout; namely, the trout which lives on entomostracæ, and comes into season in December, January, and February; and the trout, which, feeding on the buccinum, and on flies, worms, and all the common food of the common river trout, comes into season later in the spring" (p. 37). In the 'Proceedings of the Linnean Society' (Dec. 19th, 1854), Dr. Knox remarked that at first he thought this a specific form, "although anatomical investigation has not hitherto confirmed it."

Dr. Günther, *l. c.*, gave a fuller description than the previous authors whom I have quoted. He observed of this fish that it has the "body much less stout than in *S. fario* . . . . In the male sex a mandibular hook has never been observed. Maxillary

much longer than the snout, but much narrower and more feeble than in *S. fario* (see figures, p. 6); in specimens 13 inches long it extends to below the hinder margin of the orbit, and at no age does it reach much beyond it . . . . The teeth of the body of the vomer form a single series, and are persistent throughout life. Fins well developed, not rounded." He found from 49 to 90 cæcal appendages. At page 6, *l. c.*, are figured two maxillary bones, stated to be from *S. fario* and *S. levenensis**, but the drawings not being completed at their proximal extremities render it almost impossible to understand what they are intended to represent. The supplementary bone would seem to be where the most difference exists. The same author likewise remarked (p. 7) on the question of species in Salmonidæ, and gave his reasons for admitting certain forms to that rank, stating that "whenever the zoologist observes two forms distinguished by peculiarities of organization such as cannot be conceived to be the effects of an internal or external cause, disappearing with the disappearance of that cause, and which forms have been propagated and are being propagated *uniformly* through all the generations within the limits of our observation, and are yet most probably to be propagated during the existence of mankind, he is obliged to describe these two forms as distinct, and they will commonly be called species." Dr. Günther has also stated, at a meeting of the Zoological Society, that the late Sir J. Richardson had informed him that he believed the true Loch-Leven trout had disappeared from that lake.

In giving a decision on the well-known "Orange-fin" case, in 1872, the Sheriff Substitute found that "in reference to the outward silvery appearance of the fish in question, both Dr. Günther and Professor Young state that the silvery coat with which these fishes is clothed is to be regarded as a distinctive mark of their being migratory fish of the salmon kind. The assumption of the silvery coat . . . . in the case of river fish, is to be held an almost infallible test of a migratory and sea-going habit. Nor is this inconsistent with the well-known fact, that in the case of certain fish which inhabit lochs having now no communication with the sea, a similar silvery appearance is to be seen. In the case of

* The teeth in the maxilla of *S. levenensis*, in Dr. Günther's figure, are shown as directed forwards and inwards; the base of each tooth appears as if resting on the skin with its point turned towards the maxillary bone!

the Loch-Leven trout, which affords the most notable example of the phenomenon referred to, it must, however, be kept in view, as having an important bearing on the character of this fish, that the loch which it inhabits had, most probably, at one time a communication with the sea, and that the fish themselves possess in a most remarkable degree the features of the salmon and the sea-trout . . . . The fact of one of these trout having, in the course of the present trial, been regarded by Professor Young as a sea-trout, after examination, is a very strong testimony to the difference between the characteristic features of the Loch-Leven trout and those of all the non-migratory river-fish" (pp. 166, 167).

In the year 1873 Sir James Maitland commenced fish-culture at Howietoun, and selected as the form of trout which he considered would prove best adapted for this purpose the true Loch-Leven breed, the eggs of which he obtained at the lake, and from which his present stock originated *. For some years he has assisted me, and allowed every facility for examining the fish in his establishment, while I have given very particular attention to the following question, *Is the Loch-Leven trout a distinct species or merely a local race*?

The first inquiry will therefore be, On what grounds has the Loch-Leven trout been regarded as a distinct species? Can any persistent differences from other trout be shown in its external form, its internal organization, its tints, or the colour or taste of its flesh?

As to external form, the Loch-Leven trout has been said to be much less stout, its head shorter, its fins more pointed, while the rays in its caudal fin are longer than those in the burn-trout; the posterior extremity of this fin is also said to be lunated and pointed at both its upper and lower angles, and its pectoral fin is likewise pointed. Also that the male has no hook on the lower jaw; that its maxillary bone is more feeble than in any other form of trout, and that it never extends posteriorly beyond the hind margin of the orbit.

As to its body being less stout than that seen in burn-trout,

* Others have likewise stocked pieces of water with these fish, but with varying success. Thus Knox ('Lone Glens of Scotland,' 1854) remarked upon "the artificial Lake of Prestmannan, into which, some years ago, the beauteous Trout of Loch Leven had been introduced. Under circumstances highly disadvantageous they throve, notwithstanding, tolerably well, and even bred at the entrance of a small stream which mainly supplies the lake" (p. 35).

this is certainly sometimes the case, but such a character is not persistent. In the form of the body there is no difference perceptible in those fish reared in Gloucestershire, as I shall presently show, or at Mr. Andrews's establishment at Guildford, from eggs obtained from Howietoun, and young of brook-trout raised from local brook-trout eggs. As this is the case in fish reared from Loch-Leven eggs it is evident that their form ultimately depends upon local circumstances or conditions; for if they are removed to another locality where the conditions are different, the brook-trout form is at once seen. The same observations apply to the length of the head, which in some well-fed examples, and, in fact, generally in the young raised at Howietoun, is a little shorter in proportion to the length of the body than usual in the brook-trout, but this changes on their being transferred to a new home.

As to the length of the rays of the caudal fin* being longer than in the brook-trout, I have been unable to find that such is the case, either in specimens from Howietoun, from Loch Leven, or in those in the British Museum, as they seem to be absolutely identical in the two forms. In a skeleton of a female 20 inches long, I find the middle caudal ray is 2·1 inches in length, and the longest outer ray 2·9 inches; but were Dr. Günther's figures, as noted below, to be applicable to these fish, the outer ray should be 4·1 inches in length. Such proportions I have never seen in any of the thousands of these fish I have observed at Howietoun or elsewhere, not omitting those in the British Museum. Specimens having the angle of this fin pointed would appear to be young fish, often males, kept, as at Howietoun, where they are not disturbed; but in the old fishes this fin is invariably rounded at its posterior extremity.

The statement that the pectoral fin is pointed is partially correct in small specimens, as it also is in small brook-trout, but in old and well-preserved examples it is as rounded as in other races of freshwater trout †.

As to the male having no knob on the lower jaw, that likewise

* "In specimens 13 inches long, the middle caudal rays are not quite half as long as the outer ones, and in older ones they are half as long." (*Günther.*) In a specimen 13½ inches long the middle caudal ray was 1 inch in length and the outer or longest one 1⅞.

† In order to demonstrate this, dried examples of the pectoral fin taken from fishes of this race at various ages were shown at the Meeting when the paper was read.

is a most erroneous assertion *; in the one figured as a diagram, which measures 14·6 inches in length, and was 44 months old when caught in October 1886, the knob is very well developed. This knob is constantly seen in all old males of this form; while even in some old females at Howietoun a small one is occasionally perceptible.

As to the maxillary bone being "much narrower and more feeble than in *S. fario*, in specimens 13 inches long it extends to below the hinder margin of the orbit, and at no age does it reach beyond it" (*Günther*), Is this so? This statement as to where the maxillary bone extends posteriorly, first made by Dr. Günther, is not borne out by an inspection of Howietoun fish, in which in large specimens it extends from one to two diameters of the orbit posterior to the eye, and this is of normal occurrence. In an example 26 inches long it reaches to $1\frac{1}{2}$ diameter of the orbit behind the eye; the longest fish in that establishment having a total length of 27 inches. For as they become more or less sterile at from 8 to 10 years of age, to which breeding males rarely if ever attain, older fishes are not present.

Doubtless the maxilla and teeth with which it is armed are not so strong at Howietoun as in some (not all) brook-trout of the same size; and the cause of this feebleness in the jaws, which ceases under altered conditions, is immaterial to discuss, because we have no evidence pointing as to how it first commenced. Although perhaps it may be likened to what is seen in some sea-trout, it may also be observed in many loch-trout in the north of Scotland, with whose jaws I have compared those of the Loch-Leven fishes. The question, in fact, now is, what will be the result on the form and strength of the jaws and teeth when these fishes are transferred to a new locality to battle their own way in the world? Anyhow, figures of the comparative strength of the jaws in a Loch-Leven female trout and one of the brook-trout of the

* Since this paper was read, the following observation appeared in the 'Birmingham Daily Post' of Dec. 11, illustrating how erroneous statements as to specific differences in species may give rise to a possibly false conclusion:—"The big trout which was recently captured in the Birmingham Corporation Reservoir at Shustoke has been mounted by Cooper, of London, and may be seen, during next week, at Keeling's fishing-tackle shop, Digbeth. It weighed when caught $8\frac{1}{2}$ lb., and its length was 27 inches. The formation of the lower jaw shows that it was an old fish, and not one of the Loch-Leven trout with which the reservoir was stocked three years ago."

same size and sex as published by Dr. Günther are very misleading; for I cannot find such examples in the British-Museum collection showing what he has represented, neither can I in nature*.

Having thus seen that in its external form either the differences which have been stated to exist between this fish and the brook-trout are erroneous, or else liable to alteration when the fish is removed to another locality, all must allow that such non-persistent differences are no basis upon which to found a species.

As to external colour, we find Parnell asserting, as among its specific characters, "body without red spots;" and that these fish are generally seen without them up to a certain age is of very common occurrence, they being of a grey colour densely spotted with black, and if males, with the fins almost black. At Howietoun, three main types of colour are observable amongst these fish—a slaty or greenish grey, becoming lighter beneath, and the upper two thirds of the body and dorsal fin spotted with black, and the fins generally greyish black. This form of colour is prevalent up to the end of the fourth season, and may almost be looked upon as equivalent to the silvery stage of the salmon smolt or grilse, but I have never seen one over four years of age continuing this livery. The second† or adult form is of a general purplish golden, densely covered with black spots, among which some red ones are usually to be seen, and many old females get a dark line along the middle of the belly, which, as well as the under surface of the head, is more or less black in males. In one female 18 inches long, on November 24th, three bright orange spots were present on the adipose dorsal fin, which as a rule is of a lead-colour, with two or three black spots‡. The third form, which will have to be again referred to, consists of small under-

* Specimens and diagrams were shown at the Meeting.

† When old enough to feed on clams, which are about the size of marbles, this yellow colour shows itself. In some small examples, hatched in 1883, the "finger-marks" were very distinct on netting the pond at the end of November 1886.

‡ We must not forget that brook-trout vary greatly in colour even when in the same locality; thus "Ephemera" in 1853 remarked of those in the Wandle that such as "feed under the cover of the trees, or lie *perdu* under banks or artificial 'hides' during sunshine, are dark brown and yellow; those that frequent the unshaded streams with a clear sandy bottom are of a silvery hue" (p. 274).

sized fish, which, owing to sickness or some other cause, have the colours of the brook-trout, with orange-tipped adipose dorsal fins.

The question here arises whether these colours are perceptible in these fishes when removed to fresh localities. In the year 1868, the late Mr. McIvor, of the Government Gardens at Ootacamund in the Madras Presidency, succeeded in introducing some Loch-Leven trout and other European fish to that elevated region, where they are or were doing well (see Journal of the Linnean Society, Zoology, vol. xii. p. 562). In January 1876, Mr. Thomas, F.L.S., of the Madras Civil Service, sent me a specimen from the Hills which was $6\frac{1}{2}$ inches long, and on its body were red spots. In this instance it was clear that if a young Loch-Leven trout could assume red spots when removed to Asia, there was no reason why any similar movement in Europe might not occasion the same results.

The assumption of the general colours of the trout in any given locality by introduced breeds is of very common occurrence, at least after the third year. Now this is the period at which the young of the imported forms would be in a condition to be observed by the fisherman, whether angler or netter.

This is generally asserted to be owing to the imported fish having interbred with the local race, and the hybrid (as it is wrongly termed) or mongrel form has the local colours. It is therefore interesting to ascertain whether, were eggs removed to a given spot quite distinct from the waters where the parents reside, the young which emerge from those eggs would retain the colours of their parents or assume those peculiar to the locality; for if this latter occurs, it must be evident that such has been consequent upon local surroundings.

Ten thousand yearlings from Howietoun were turned into Loch Goldenhove, about two miles away, and fed by the same stream which passes through the fish-farm; this loch is nine acres in extent, and averages six feet in depth. In July 1886, I examined some of these introduced fish, and found them of a purplish colour shot with gold, and covered with black ocellated spots, but no red ones. Dorsal fin spotted with black, but without any white edging, its outer surface greyish; a little orange upon the adipose dorsal fin. The colours, in fact, of these fish were not what is seen in the Howietoun ponds, but nearly approaching those in the Loch where they had been placed. A few had some red

spots. As the water in the two localities was the same, food would seem to have been the principal reason of this change in colour.

Although the last experiment does not prove very much, it shows that some alteration in colour may follow new environments; but a still more conclusive result as to the change in colour which may take place in these fish under like circumstances has lately occurred in Gloucestershire. The present proprietor of Cowley had two ponds in a wood on his estate, each about an acre in extent, and from the lower of which springs a small stream; these he wished to have stocked with some good kinds of sporting fish. The two ponds are supplied by underground springs, while there is a fall of about 16 feet from the outlet of the upper pond, and a rather greater one from that of the lower where the stream commences. It will thus be apparent that no fish could obtain access from above, neither could they ascend the 16-feet perpendicular fall from the stream to the lower pond. It was determined to try the Loch-Leven trout; so these ponds were drained, mudded, and then puddled with clay.

During December 1884 and January 1885 one thousand yearling Loch-Leven trout were received from Mr. Andrews of Guildford *, and these were placed in the ponds by Mr. Ogden, of Cheltenham. In August this year (1886) I was informed that, it having become necessary to remove these fish to a more suitable locality, they had been capturing them, and very great differences were perceptible both in size and colour among the two sets of fish—those in the upper pond being silvery with a few black spots, whereas those in the lower pond were of a much larger size, covered with spots, and having purple and golden reflections. Having obtained leave, we visited these ponds on August 25, and first examined the temperature of the water by means of thermometers, when we found that they scarcely differed. The lower pond was the deeper, and in it were large quantities of the American weed, *Anacharis Alsinastrum*, also some *Chara*, while on the surface was a considerable amount of the water crowsfoot (*Ranunculus aquatilis*); whereas in the upper pond there were fewer weeds, but some *Pimpinella Saxifraga* was present near its upper end.

* Mr. Andrews, of Westgate House, Guildford, wrote (September 14, 1886):—"The yearling fish supplied to Mr. Ogden, of Cheltenham, in 1885, were Loch-levens reared from eggs which were sent me from Howietoun. There can be no doubt of their being from ova from Stirling, as they were put in a pond quite distinct from the others on a different water-shed."

It seemed, so far as we could ascertain, that more animal pond-life was present in the lower pond among the greater amount of vegetation, especially the sessile-eyed crustaceans *Gammarus pulex* and water-snails (*Limnæa ovata*, variety *peregra*). These forms were, however, also present in the upper pond, where a small water-newt was also netted. During the month of April this year, when investigating the stream which issues from the lower end of these ponds, I found enormous numbers of tadpoles and the larvæ of Ephemeridæ and their allies.

A fish captured in the upper pond was seven inches long, its colours generally silvery with a golden abdomen, and a few black spots along the sides, three of which were below the lateral line and two on it, as well as three red ones; cheeks silvery yellow, abdomen golden. Some spots on the rayed dorsal fin, which had a white black-based edge at its upper angle; while the ventral and anal fins had a very distinct white black-based edging. Upper and lower rays of caudal fin and the upper end of the adipose dorsal orange-edged. 52 cæcal appendages. A male, but sterile. The appearance of this fish as to colour was, Mr. Ogden observed, similar to the others removed from the pond.

Two fishes were taken from the lower pond, one ten, the other eleven inches long. They were generally purplish, with golden reflections. The side of the body (of one which was most critically examined) from the upper edge of the pectoral fin to and above the lateral line was closely dotted with ocellated black spots, while there were also some red ones, five of which were on the lateral line. Cheeks golden; abdomen golden, becoming white on the chest. Dorsal fin with numerous spots, and a pink black-edged upper angle. Adipose dorsal with a red edge and several black spots. Pectoral and ventral chrome with white edges, base dark. 62 cæcal appendages. A male, with the generative organs well developed. 22 small shells of *Limnæa* in its stomach.

As regards the colour * on the adipose dorsal fin, I examined at Howietoun, on August 15th, 1886, a number of two-year-olds,

* An interesting occurrence has taken place at Cowley among these fish, which would seem to prove that Lochlevens throwing back to brook-trout may be consequent upon a diminished supply of food causing deterioration. During the last week in November Mr. Ogden was near this lower pond and saw a large trout rise; so he returned to the house, and having obtained his fishing-tackle, made a cast over it and captured it at the first throw. The fish proved to be 15 oz. in weight and in good condition, but was described to me as having

with the result that there was merely a trace of orange visible in some, but the black white-edged margin to the rayed dorsal and anal fins was not uncommon.

On July 5th, 1886, I examined the colour of the adipose dorsal fin in many Lochlevens, from pond 9; the first was rising 2-years, and was five inches long. It had two black spots on the adipose dorsal but not a trace of orange, and no red spots on the body. Several more subsequently looked at were the same. Three had a slight orange tinge on the adipose fin, and likewise a few red spots on the body; in fact this fin was orange-tinted in all, wherein red spots existed on the sides, but the presence of these red spots was the exception, not the rule. Passing on to the nursery-ponds, we examined a few undersized Lochlevens which had not fed well; all had their bodies red-spotted and also red on the adipose dorsal fin, while the rayed dorsal had a more distinctly black white-edged margin than was generally seen. Some of the fish had 2, 3, or 4 black spots on this fin. These fish would at once have the brook-trout livery and not pass through the normal silvery stage—a stage, we have been erroneously informed, which is an infallible test of a trout being migratory and sea-going.

Having paid a visit to Mr. Andrews's* well-known fish-cultural establishment at Guildford, I was shown the yearling Lochlevens which had red spots and red edges to the upper margin of the adipose dorsal fin and on each lateral margin of the tail-fin.

Here I must shortly digress to describe a hybrid specimen raised at Howietoun, which possibly affords one of the most convincing proofs that could be adduced of the identity or close

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been nearly black, while it was the largest fish that has been seen. From the fact that this pond lately had had very few fishes in it (they having been removed), a more abundant supply of food was obtainable, and consequently this trout had grown larger and taken on the Loch-Leven trout colours.

* Mr. Andrews (MS., Nov. 1886) finds at Guildford that "eggs of the Loch-Leven trout from Howietoun do very well with him; they are hatched in water coming from chalk, and reared where it comes from a gravelly soil. The young grow more rapidly and are deeper in form than seen at the same age in their native home. The yearlings have the edge of the adipose dorsal fin and sides of the tail-fin red, and there are also some red spots on the body, in common with young of the brook-trout and some reputed as *S. ferox*." Mr. Andrews continues that he "knows of no *unmistakable peculiarities* observable in the foregoing three varieties of British trout;" and I question if any one else is able to point out their existence.

relationship of the Loch-Leven and burn-trout. In November, 1883, some eggs of a Loch-Leven trout were milted from a salmon-parr at Howietoun (which specimen I still possess in spirit), and hatched in March 1884. As I have elsewhere related, most of the young died of dropsy, but a few lived, and some are still at Howietoun in pond 16, very many being small, but a few of fair size, some even giving eggs and milt this season. On November 24th I removed one of these fish, a beautiful parr, showing the long pectorals and large caudal fin of the salmon, but having only nine finger-marks; while as to colours it was of a beautiful silvery glossed with gold, the rayed dorsal fin rather densely spotted with black, some of the spots having a deep scarlet edging, and a white margin with a dark base being present at the front upper corner of this fin as well as of the anal. Adipose dorsal red-edged; caudal straw-coloured, with red upper and lower edges. Numerous black spots in the upper half of the body, also some red ones, but most of the latter along the lateral line and some below it. A large black spot on opercle and some smaller ones.

Here was a hybrid showing the number of bars of the trout, and also most of the trout-colours, but with this remarkable variation from the Loch-Leven breed, that the orange edging was present on the adipose dorsal * and the light edging on the dorsal and anal fins. In fact the spots on the dorsal fin closely resembled those seen in the burn-trout in Sutherlandshire. Unless the Lochlevens have burn-trout blood in them, how could these fish possibly throw back to the colours of the latter race?

It is normal for the adipose fin of the Loch-Leven trout to have black spots upon it, but no orange margin. The reason is probably similar to that which causes these fish to have no orange spots on the body, because if orange spots exist upon the body the adipose dorsal is also orange-tipped. Evidently whatever causes this coloration in one part of the body equally does so in the other.

As to the internal organization of the Loch-Leven trout, we have been told that it possesses from 49 to 90 cæcal appendages, and that the teeth along the body of the vomer "form a single series, and are persistent throughout life." In fact from the time Parnell first ascertained that these trout often possess a larger

* Not only is the adipose dorsal normally destitute of an orange edging or orange spots in both young salmon and young Lochlevens, but this colouring is present in many sea-trout with which young Lochlevens have been compared.

number of these appendages than are usual in brook-trout until the present day this has been held conclusive evidence as to their specific difference from other forms. Many who would admit that variations in external colour or in that of the flesh, or even alterations in form, may be dependent on local surroundings, will be slow to believe that structural differences are not of much greater value. Hence we must first inquire whether the number of these cæcal pylori are constant in the Loch-Leven race of trout, whether they ever vary in the brook-trout, and, lastly, if any facts can be produced proving them to be inconstant.

Among the local Loch-Leven forms we are told by Parnell that the cæcal pylori are from 60 to 80 in number. Sir J. Richardson found 73 in each of the three which he dissected, and Günther from 49 to 90; and although in the description of the species the latter writer says, "Cæcal pylori normally 60 to 80," he instances seven females in the British-Museum collection as follows :—"Females, from 12 to 18 inches long. Purchased, said to be from Loch Leven. Caught in April. Cæcal pylori 65, 63, 60, 54, 54, 53, 49; vertebræ 58–59. These specimens have the pyloric appendages fewer in number than is generally stated; yet these cæca are so wide—so much wider than in *S. fario*, that the reduction of their number has evidently been caused by a confluence of several cæca into one" (Catal. vi. p. 101).

From the foregoing statements it is evident that the number of these appendages is very variable, for we have them stated as being from 49 to 90. If, however, we turn to the writings of most authors who have counted the cæcal pylori in *S. fario*, we find them enumerated as follows :—"I have never found them to exceed 46" (Parnell, 'Fish Firth of Forth,' p. 308). Thompson in 1836 examined the so-called *S. ferox*, and found in four examples 49, 45, 39, and 36 ('Nat. History of Ireland,' iv. p. 157). Günther among his other five non-migratory freshwater forms enumerated them as varying from 33 to 49.

Having thus shown that these appendages in the Loch-Leven trout have been recorded as between 49 and 90, while in other non-migratory freshwater forms they have been found to be between 33 and 49, I propose enumerating some which I have counted in examples of this fish. Among *males*, in specimens varying from 7 to 20½ inches in length, I have found them as follows :—At Howietoun, 8 examples of fertile fish averaged about 67 cæcal appendages, founded on these numbers—82, 75, 74, 73, 65, 62, 62, 48.

At Cowley, in Gloucestershire, one fertile male had 62, one which was sterile 52. Among *females*, varying in length from 12 to 22 inches, the number of these appendages in 7 examples of fertile fish averaged about 58, derived from the following numbers —66, 64, 62, 59, 57, 55, 45; while one large female from Loch Leven had 47. As a rule these cæca appear to be larger in females than in males, while in one of the latter a single one of these tubes was abnormally shortened near the pylorus.

The foregoing figures show a variation at Howietoun in the number of these appendages, ranging from 48 to 82 in male fish, and from 45 to 66 among female fish; while in one male which was fertile, examined in Gloucestershire, there were 62, and in another, not so well fed, from the same locality, and sterile, there were 52. In only one is the number seen to approach 90 (82) as given by Dr. Günther, and with that exception 75 was the largest number counted, and from that down to 45, clearly showing that this is an unstable character, prone to change, and consequently unsuitable for discriminating species. Also that, away from Loch Leven, these appendages have diminished in number, and still more so in examples from the ova hatched at Guildford and reared in Gloucestershire, where the smallest fish were sterile and had the fewest of these appendages. As to the diameter of the cæca, the difference was not apparent, except so far as I have mentioned above.

Possibly the number of the cæcal appendages may, under certain circumstances, be found of value in ascertaining whether the food on which the fish subsist is of such a nature that they will thrive or deteriorate.

If these appendages decrease when the fish are transferred to other localities, it may be asked if instances can be adduced where they have ever been found to increase in trout when removed to better feeding-grounds or improved conditions of life*. The eggs sent from the brook-trout of Hampshire and Buckinghamshire by Mr. Frank Buckland and Mr. Francis Francis to Tasmania have developed into a large race, in which the cæcal pylori seem to have reached the normal number of 52, showing a considerable augmentation, and again proving the number of these organs to be inconstant.

Respecting the vomerine teeth being in a single series in Loch-

* Since this paper was read (viz. in March 1887) young rainbow-trout (*Salmo iridens*), 22 months old, raised at Howietoun, have been examined. In California, whence the eggs were received, these fish are said to possess about 40 cæcal appendages; in one dissected at Howietoun I found 71.

Leven trout, but in a double row in burn-trout of the same size, we have first to consider whether the facts as stated are correct. All trout and salmon (not charr) when young, irrespective of the teeth on the head of the vomer, have a double row along its body; but these in all are dependent on age or rapidity of growth, and fall out, commencing behind and extending forwards. In salmon and sea-trout, which are forms that grow most rapidly, these teeth are shed the earliest, while the Loch-Leven trout, which is likewise a rapid grower, loses them rather sooner than the burn or loch form; hence to say that in the mature examples they *are invariably* in a single row is erroneous. At the same time it is not here advanced that rapidity of growth is the sole cause of this, for the deciduousness of the teeth appears to be owing to the absorption or narrowing of the tooth-bearing ridge on the vomer, in consequence of which the teeth, originally placed in pairs, become ultimately ranged in a single row and finally fall out.

The condition of the vomerine dental system in specimens of Loch-Leven trout may be thus recorded:—(1) ♀ 20 inches long, 2 teeth exist on the hind edge of the head of the vomer, and 3 along the front half of its body, the first two of which are almost opposite one another. (2) ♂ 9 inches long, 2 teeth at hind edge of vomer, 2 at the front end of the shaft, and 7 in an irregular zigzag line, almost in one continuous row, while their points turn alternately to the right and left. (3) ♀ 10·9 inches long, 2 at hind edge of head of bone, 2 in a line at the commencement of the body, and 8 as in the last but more distinctly in pairs. (4) ♀ 13·5 inches long, 2 at hind edge of head of vomer, then 4 in a single row, next a pair turning one to each side, and lastly 4 more single ones. (5) ♂ 14 inches long, 2 teeth at hind edge of head of vomer, 9 in a single row along the body of that bone; of these the two central ones form a pair. (6) ♀ 19·2 inches long, 4 teeth at hind edge of body of the vomer, 12 along the body, among which are three pairs. (7) ♀ 23 inches long, 3 at hind edge of head of vomer, 8 along its body in a single row, some turning one way and some another. The foregoing seven specimens show that it is by no means an invariable rule that all the teeth along the body of the vomer are in a single row.

Having examined a considerable number of burn or loch trout in Sutherlandshire, I found that the maxillæ were not stronger than in the Lochlevens, while a specimen * taken at random

* Exhibited when the paper was read.

shows the same dentition as in the form under discussion: burn-trout, ♂ 11 inches long, 2 teeth at the hind edge of the head of the vomer, 10 in almost a single line along the body of that bone, turning alternately right and left at their points, but in only one instance are they in a pair. Further south, as in the Windrush in Gloucestershire, the maxillæ are stronger and the vomerine teeth are more nearly in a double line than in more northern specimens; but an entire series, showing all these grades of variation, may be traced in freshwater trout in most localities where I have searched for it.

The colour of the flesh of the Loch-Leven trout is said to be deep red, and it is reputed to be very good eating. Whether the flavour of these fish has or has not deteriorated since the partial draining of the lake, as asserted by some and contradicted by others, must ever remain unsolved, because how the fish were cooked, the degree of hunger in the partakers of the food, and many other circumstances would have also to be taken into account; while deciding such a question from recollection would be a rather doubtful proceeding. There is a legend that in olden times these fish never took a fly; and an anonymous writer in 1886, commenting upon the bad luck which had attended an angling competition, observed that fly-fishing on Loch Leven had been in existence for about 25 years, but previous to that time these fish showed no disposition for winged prey. Granting the general accuracy of this statement would seem to partially confirm the opinion of Parnell and some others, that the local food has diminished in amount, and therefore these fish will now take the fly. Why the charr has disappeared from this lake is not material to the present inquiry.

As food Parnell held that at Loch Leven the flesh of this form of trout is of a dark red, but in the common loch or burn-trout pinkish or often white. This, however, cannot be held as distinctive of species, for some trout captured on the same day at Loch Assynt, in Sutherlandshire, showed all variations in the colour of their flesh, from white to red, and were all equally well tasted. Parnell also observed that "James Stuart Monteith, Esq., of Closeburn, caught a number of small river-trout, and transferred them to a lake (Loch Ettrick), where they grew rapidly; their flesh, which previously exhibited a white chalky appearance, became in a short time of a deep red, while their external appearance remained the same from the time they were first put in" (*op. cit.* p. 307).

Mr. Ffennell, writing of the Lochlevens at Mr. Andrews's (*Times*, Oct. 14th, 1886), observed that "the Loch-Leven trout were no strangers to me; I have killed many, and as a fresh-water fish I hold them in high esteem: and I certainly think that those I took from the roadside pond in Surrey were the very best I had ever placed before me."

The question whether the Loch-Leven trout is a local race or a distinct species, is one of considerable practical importance to the fish-culturists of this country, quite irrespective of its scientific interest. If it is a species distinct from the brook-trout, its introduction into our streams and dissemination through our fresh waters would be a great source of hybridization among our indigenous forms, and this would tend towards sterility of the offspring. On the other hand, if it is merely a local race, its crossing with the brook-trout would be merely the inter-breeding between two varieties of one species, which, instead of being a cause of sterility, is more commonly a means of improving a breed.

I assume it as granted that the Howietoun fish are in every respect similar to those of Loch Leven, whence the breed was derived. This variety is sometimes, not always, finer shaped towards the tail, and has a rather shorter head, as in the sea-trout, *S. albus*, than the ordinary brook-trout, while its form is much like that of the *Salmo lemanus* or loch-trout of the Lake of Geneva and elsewhere, which has been shown to be a variety of *S. fario*. Its maxillary bones are somewhat finer than in our ordinary river-trout; its cæcal appendages are more numerous; and its colour differs, being as a rule silvery with black, but having no red spots up to its fourth or fifth year. Dr. Günther's observations that the male never has a knob on the lower jaw, that its fins are never rounded, that the teeth along the body of the vomer are always in a single row, very different from those of the brook or burn trout, may be dismissed as erroneous statements, probably made owing to the want of opportunity of examining specimens. The Loch-Leven trout is doubtless a rapid grower in its northern home, and the race at Howietoun has been much improved by selection of breeders; but removing the eggs to a new locality and then rearing the young has shown that the form and colour of the local race of trout is, as a rule, assumed, while even the number of cæcal appendages becomes altered, owing to changed condition of life.